Base K/Round 4 Modeling: Summary (DRAFT)

The purpose of this document is to summarize the results of the latest 2002 base year (Base K) and 2008, 2009, 2012, and 2018 future year (Round 4) modeling[1]. Based on these results, several key findings should be noted:

- Model performance for ozone and PM2.5 (most species) is acceptable and, thus, use of the model for planning purposes is appropriate. Comparisons of modeled and monitored ozone and PM2.5 (most species) concentrations generally shows good agreement. PM2.5-organic carbon concentrations, however, are not well represented by the model.

- Existing ("on the books") controls are expected to provide considerable improvement in air quality, but will not be enough to provide for attainment at all monitoring locations for ozone and PM2.5. Additional emission reductions are needed for attainment.

- Attainment by 2009 for ozone and PM2.5, even with consideration of additional emission reductions, appears to be difficult. Attainment by 2012 appears to be possible with a combination of existing controls and several candidate control measures.

- Additional emission reductions also appear to be necessary to meet the initial reasonable progress goal for regional haze in the northern Class I areas. (Note, a determination of reasonable progress is pending based on assessment of the four statutory factors.)

Three additional analyses were performed using the Base K/Round 4 emissions: (1) 4 km ozone modeling, (2) ozone and PM2.5 source apportionment, and (3) alternative modeling as part of a weight-of-evidence demonstration. These analyses are summarized in separate documents.

Base Year Modeling Results

The purpose of the base year modeling is to evaluate model performance by comparing modeled and monitored concentrations. The results for ozone and PM2.5 are presented below.

Ozone: Spatial and time series plots are provided for a high ozone period in June 2002 (see Figures 1 and 2). These plots show that the model is doing a reasonable job of reproducing the magnitude, day-to-day (and hour-to-hour) variation, and spatial pattern of ozone concentrations. There is a tendency, however, to underestimate the magnitude of regional ozone levels.

In addition, time series plots using ozone precursor (VOC and NOx) concentrations were prepared using data from the PAMS sites in the Lake Michigan and Detroit areas (see Figure 3). The plots show reasonable agreement between modeled and monitored concentrations.

Standard model performance statistics were generated for the entire 12 km domain, and by day and by monitoring site. These results also indicate a tendency to underestimate ozone levels (e.g., normalized bias is about -10% for domainwide average).

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[1] Additional details about the modeling, including grid projections and domain, model inputs, and quality assurance, are provided in "Addendum Modeling Protocol: Technical Details", Lake Michigan Air Directors Consortium, August 22, 2006

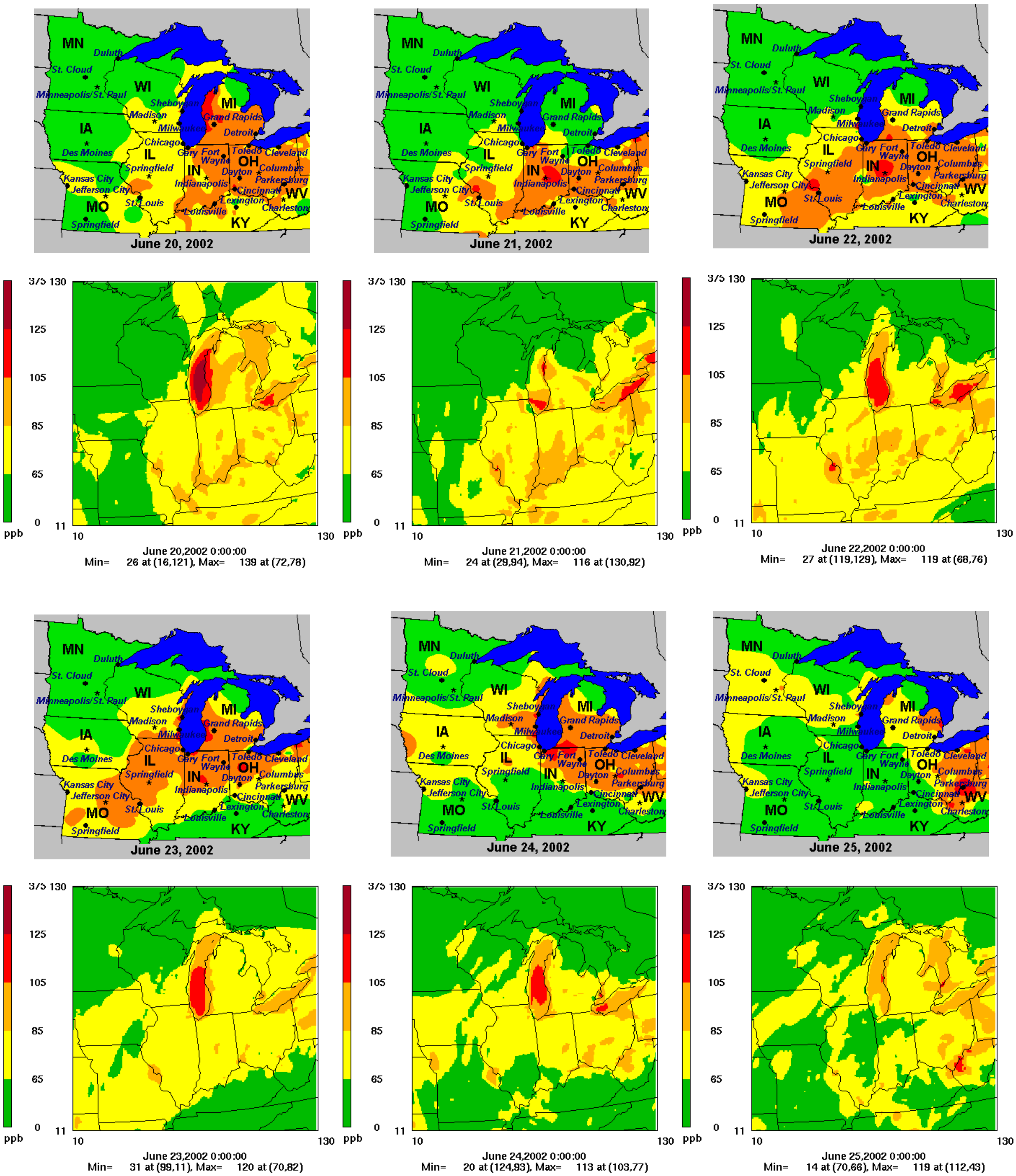


Figure 1. Monitored (top) v. Modeled(bottom) 8-Hour Ozone Concentrations: June 20 – 25, 2002

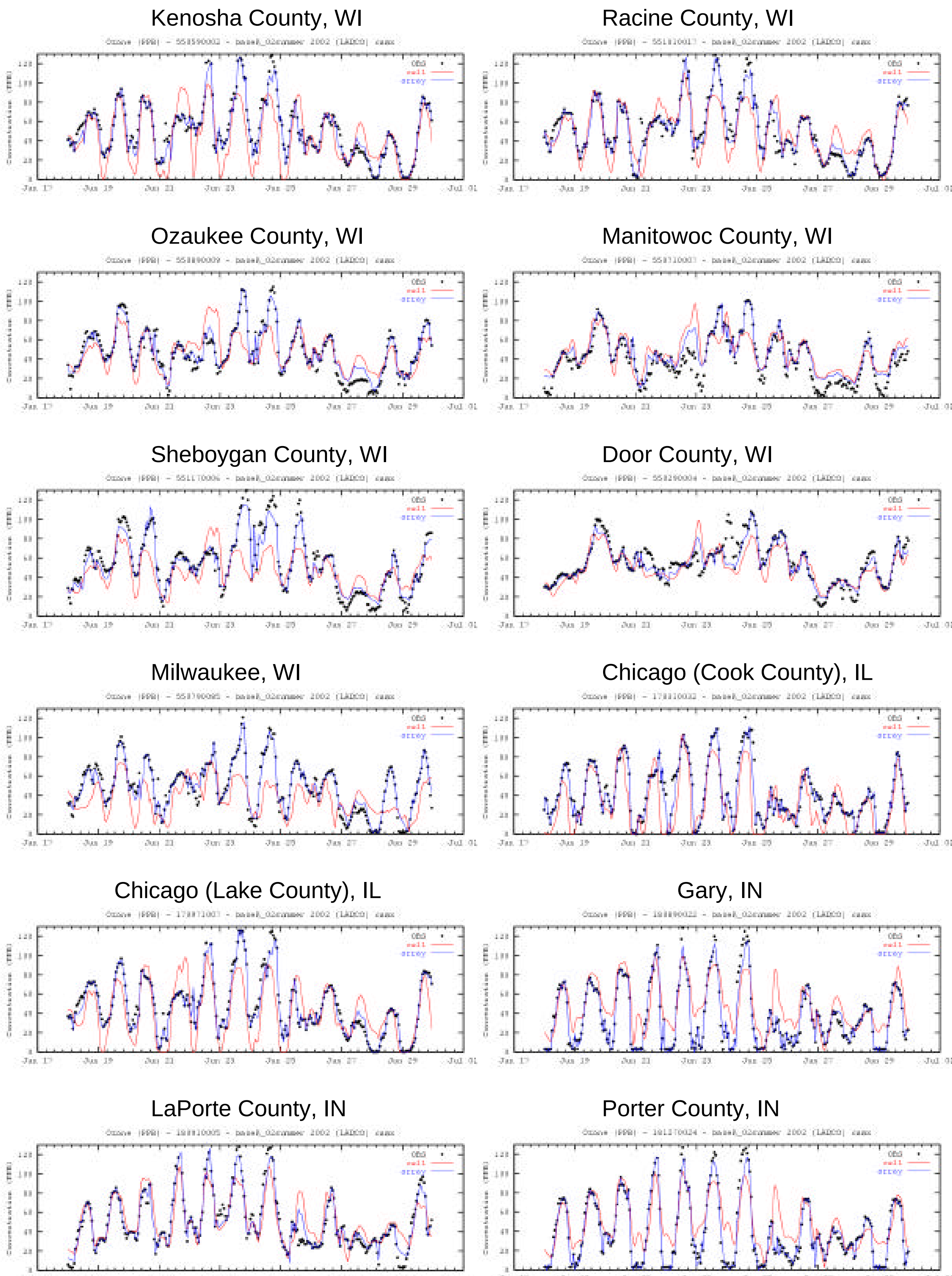


Figure 2. Monitored v. Modeled Hourly Ozone Concentrations: June 18 – 30, 2002

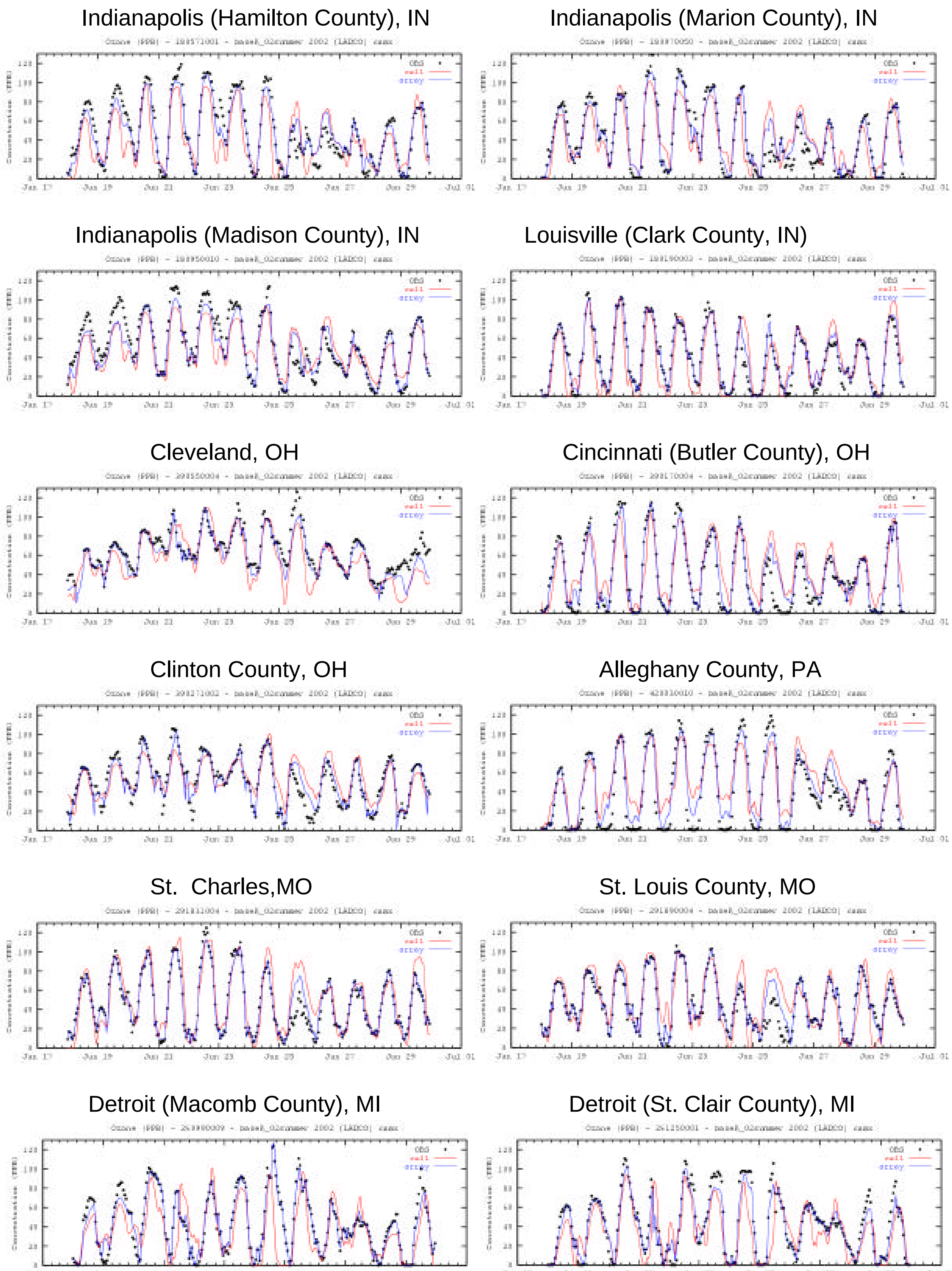
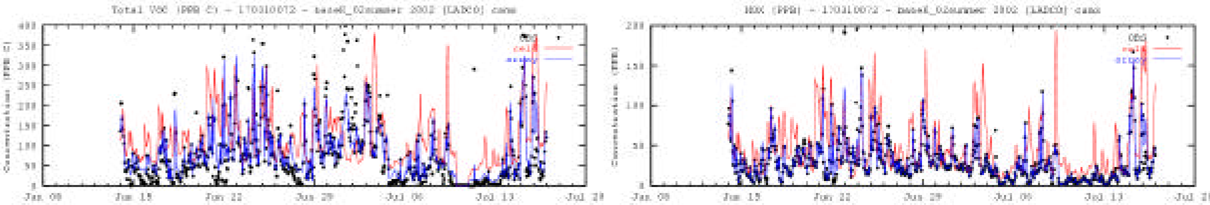
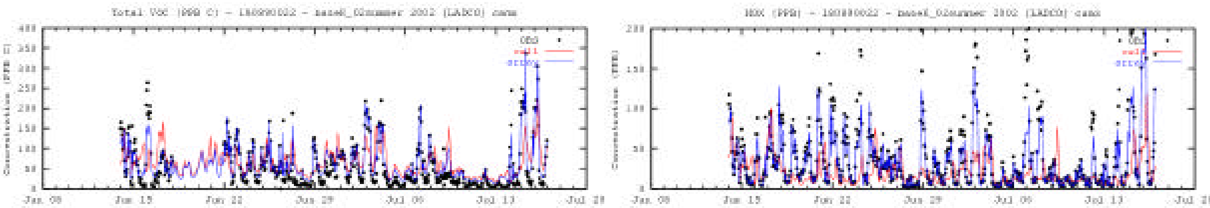


Figure 2. Monitored v. Modeled Hourly Ozone Concentrations: June 18 – 30, 2002 (continued)

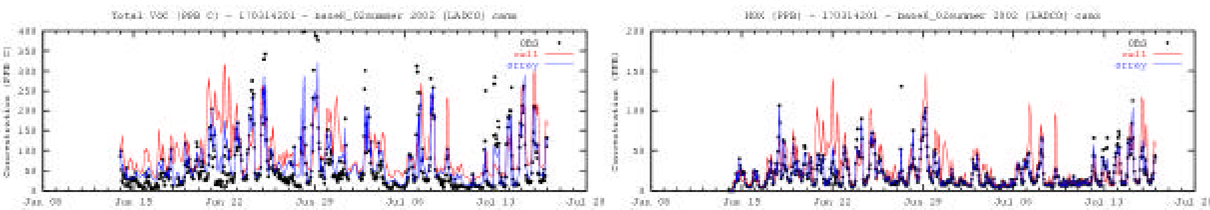
Chicago, IL



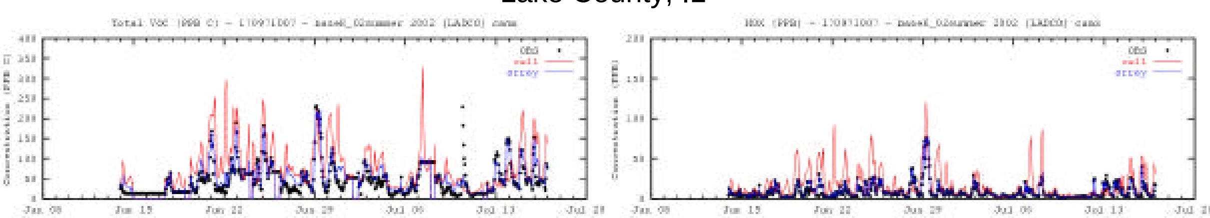
Gary, IN



Northbrook, IL



Lake County, IL



Detroit, MI

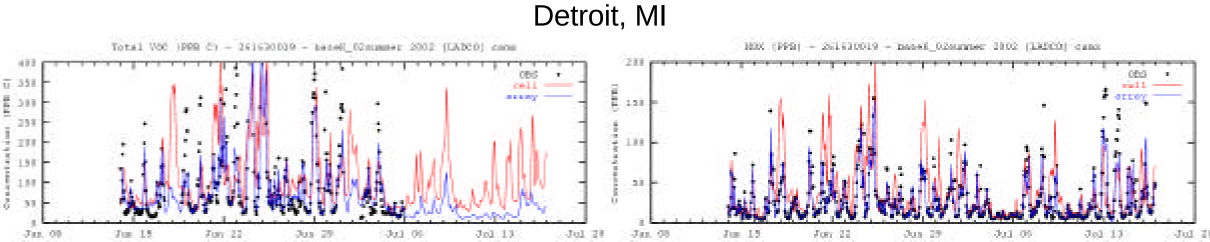


Figure 3. Monitored v. Modeled VOC (left side) and NOx (right side) Concentrations: June 18–30, 2002

PM2.5: Time series plots of the monthly average mean bias and gross error, and annual fractional bias and fractional error for Base K (and Base J) are shown in Figure 4. As can be seen, the model performance results for sulfates, elemental carbon, and soil for Base K are good, and are similar those for Base J. The Base K results for nitrates are much better those for Base J, although they still show a tendency to overestimate monitored values. The Base K results for organic carbon, however, are still poor, especially during the summer months, suggesting the need for more work on primary organic carbon emissions and model chemistry (secondary aerosol formation). (Note, work is underway to improve biogenic emissions and model treatment of secondary organic aerosolos, but better understanding of primary organic carbon emissions from mobile sources is needed.)

Scatterplots of daily sulfate, nitrate, organic carbon, and elemental carbon concentrations for each month are provided in Figure 5. Time series plots of daily sulfate, nitrate, elemental carbon, and organic carbon concentrations for two locations (Chicago and Indianapolis) are presented in Figure 6. These results are consistent with the model performance statistics (i.e., good agreement for sulfates, reasonable agreement [albeit slightly high] for nitrates, and poor agreement [large underprediction] for organic carbon).

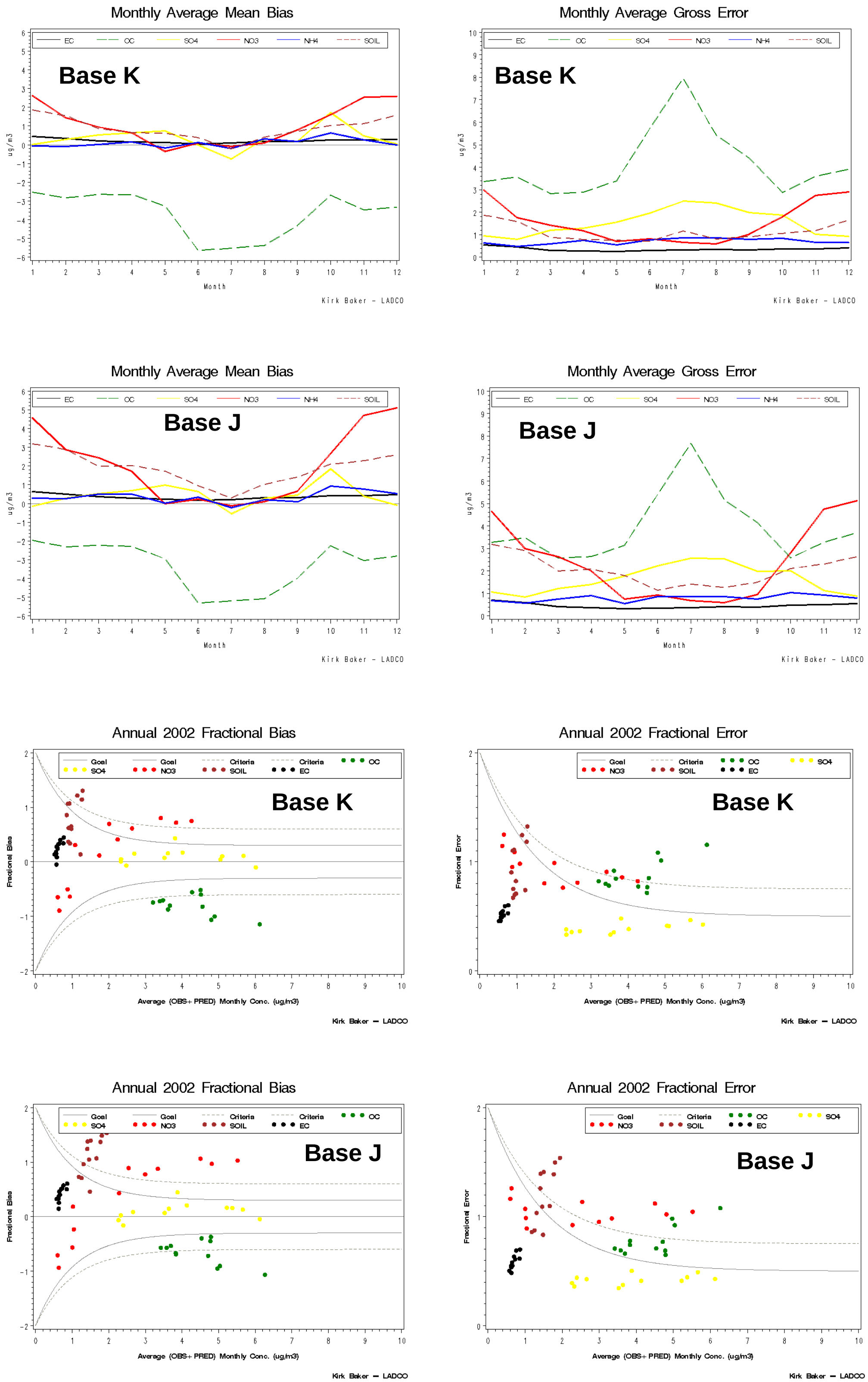


Figure 4. PM2.5 Model Performance - Monthly Average Mean Bias and Gross Error, and Annual Fractional Bias and Gross Error for Base J and Base K

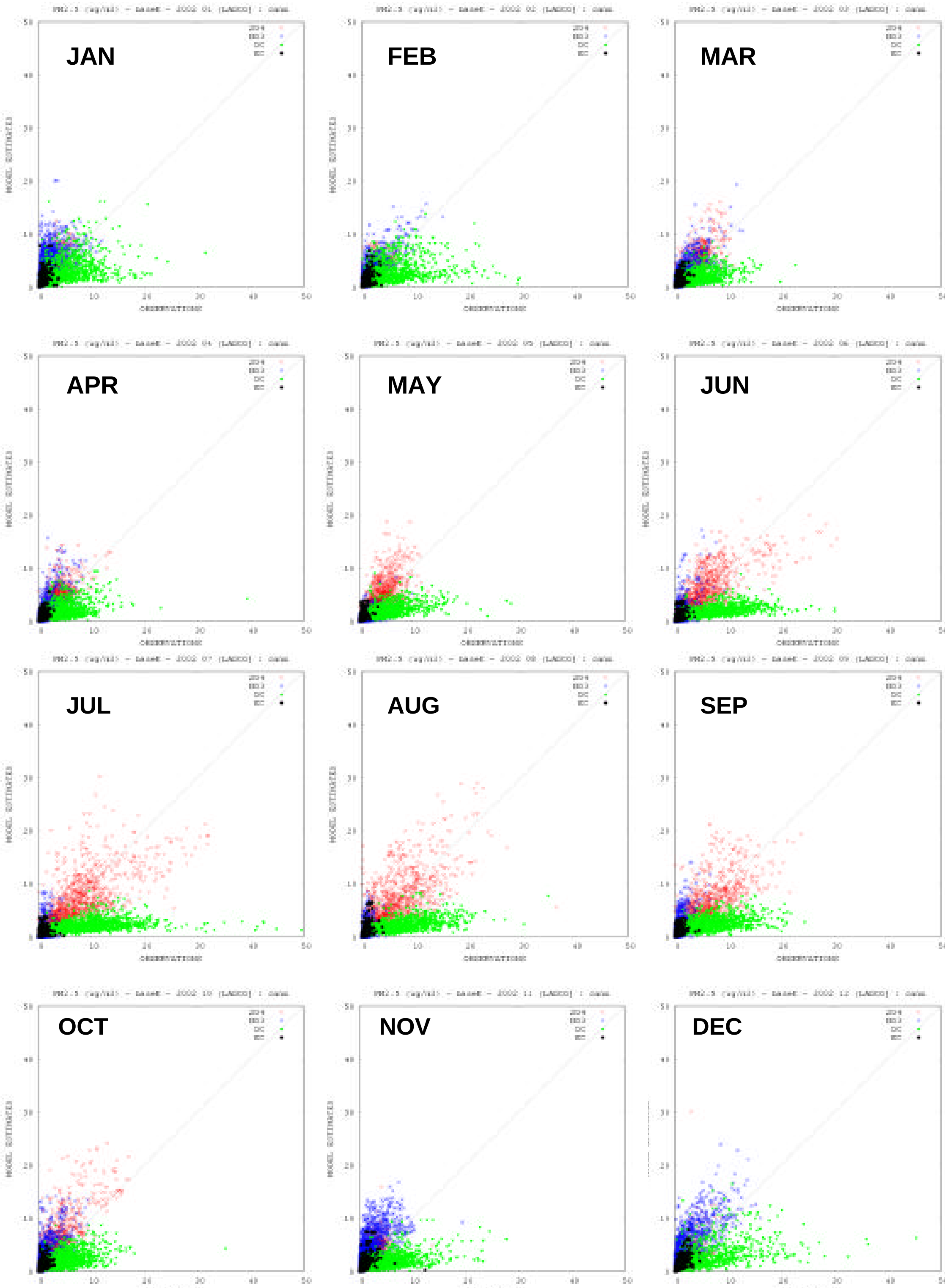


Figure 5. PM2.5 Model Performance – Monthly Monitored v. Modeled Concentrations by Species

Figure 6. PM2.5 Model Performance – Time Series ofConcentrations by Species

Future Year Modeling Results
The purpose of the future year modeling is to assess the effectiveness of existing and possible additional control programs. The future year modeling scenarios are listed in Table 1, and the modeled ozone and PM2.5 concentrations are provided in Table 2.[2]

Scenario 1: This scenario represents the future year "base" inventory (i.e., growth to the future year of interest and application of existing ["on the books"] controls). The following controls were included in this scenario:

On-Highway Mobile Sources
- Tier II/Low sulfur fuel
- Inspection/Maintenance programs (nonattainment areas)
- Reformulated gasoline (nonattainment areas)

Off-Highway Mobile Sources
- Federal control programs incorporated into NONROAD model (e.g., nonroad diesel rule), plus the evaporative Large Spark Ignition and Recreational Vehicle standards
- Heavy-duty diesel (2007) engine standard/Low sulfur fuel
- Federal railroad/locomotive standards
- Federal commercial marine vessel engine standards

Power Plants
- Title IV (Phases I and II)
- NOx SIP Call
- Clean Air Interstate Rule
- Clean Air Mercury Rule

Other Point Sources
- VOC 2-, 4-, 7-, and 10-year MACT standards
- Combustion turbine MACT
- Industrial boiler/process heater/RICE MACT

Four versions of Scenario 1 were considered:

1a reflects the full trading version of CAIR (based on IPM modeling – VISTASII_PC1f run that was developed for VISTAS in 2005, which incorporates the EPA 219b fuel prices, RPO-directed NEEDS, regional and state environmental regulations, and run year updates)

1b reflects a restricted trading version of CAIR (based on IPM modeling – VISTASII_PC3b run that was developed for VISTAS in 2005, which is similar to VISTASII_PC1f with the addition of state-level emission caps for CAIR and CAMR)

1c reflects the full trading version of CAIR (based on IPM modeling) and BART for select non-EGUs

1d reflects the full trading version of CAIR (based on IPM modeling) with emissions scaled-back to match the state-level CAIR emission caps (note, unlike 1b, this scenario does not allow for banking and, consequently, results in lower emissions compard to 1b)

[2] Another scenario (Scenario 6) was also modeled for 2012 (36 km annual PM2.5 run and 12 km summer ozone run). This scenario reflects an initial set of possible state control measures. Given the cursory nature of this set of measures and the need to make several emissions inventory approximations, the results of this scenario are considered preliminary and are not included here.

Table 1. Round 4 Strategy Modeling Runs

Run		Description		2002	2008	2009	2012	2018
Base K		2002 baseyear emissions inventory		*36,12*				
Scenario 1		Existing (OTB) controls, plus CAIR						
		a. CAIR w/ full trading			*12*	*36,12*	*36,12*	*36,12*
		b. CAIR w/ restricted trading					*36,12*	
		c. CAIR w/ full trading and BART for non-EGUs						*36*
		d. EGU0 - CAIR w/ full trading scaled-back to state budgets				*36,12*	*36,12*	
Scenario 2		Scenario 1a plus EGU controls:						
		a. EGU2 for top 30 EGUs in 5-state region (based on Q/d)					*36,12*	
		b. EGU2 in 100 km radius of each residual NA area					*36,12*	
		c. EGU2 in 5-state region				*36,12*	*36,12*	*36*
		d. EGU2 in 12-state Midwest region					*36,12*	*36*
		e. EGU1 in 5-state region				*36,12*	*36,12*	
		f. EGU1-IPM in 5-state region					*36,12*	
		g. EGU2-IPM in 5-state region					*36,12*	
Scenario 3		a. Scenario 2 e plus "low" control level for non-EGU point, area, and mobile sources throughout 5-state region				*36,12*	*36,12*	
		Non-EGU Point Sources						
		* ICI Boilers - 40% SO2, 60% NOx reduction (ICI1)						
		* Glass manufacturing - 30% NOx reduction (GLASS1)						
		Area Sources						
		* Consumer products - OTC model rule (SOLV2A)						
		* AIM coatings - OTC model rule (SOLV1A)						
		* Portable fuel containers - OTC model rule (SOLV3A)						
		* Auto refinishing - extend IL.IN,WI RACT rules (SOLV4A)						
		* Ind. surface coating - more stringent RACT (SOLV5A)						
		* Degreasing – more stringent RACT (SOLV6A)						
		* Gas. Dispensing - enhanced vapor recovery (SOLV7A)						
		Mobile Sources						
		* HDDV – reflashing and voluntary measures <$5,000/T						
		* Construction Equipment - voluntary measures < $5,000/T						
		* Low RVP fuel (IN, MI, OH counties)						
		b. Scenario 2 c plus "high" control level for non-EGU point, area, and mobile sources throughout 5-state region				*36,12*	*36,12*	
		Non-EGU Point Sources						
		* ICI Boilers - 90% SO2, 80% NOx reduction (ICI3)						
		* Cement kilns – 90% SO2, 50% NOx reduction (KILN1)						
		* Asphalt plants – 25% NOx reduction						
		* Glass manufacturing - 75% NOx reduction (GLASS2)						
		Area Sources						
		* Consumer products - SCAQMD rule (SOLV2B)						
		* AIM coatings - CARB 2003 rule (SOLV1BA)						

		* Portable fuel cont, - Accelerated phase in (SOLV3B)						
		* Auto refinishing - SCAQMD rule (SOLV4B)						
		* Ind. surface coating - more stringent RACT (SOLV5A)						
		* Degreasing - more stringent RACT (SOLV6A)						
		* Gas. dispensing - enhanced vapor recovery (SOLV7A)						
		* Asphalt paving applications - low VOC formulations						
		Mobile Sources						
		* HDDV - reflashing and voluntary measures <$10,000/T						
		* Const. Equipment - voluntary measures < $10,000/T						
		* Agricultural Equipment - voluntary measures < $10,000/T						
		* Low RVP fuel (IN, MI, OH counties)						
Scenario 4		**Non-EGU Point Sources**					*36,12*	
		* ICI Boilers - 40% SO2, 60% NOx reduction (ICI1)						
		Area Sources						
		* Consumer products - OTC model rule (SOLV2A)						
		* AIM coatings - OTC model rule (SOLV1A)						
		* Portable fuel containers - OTC model rule (SOLV3A)						
		Mobile Sources						
		* HDDV – chip reflashing						
Scenario 5		EGU Point Sources					*36,12*	
		*** EGU1 for SO2, EGU2 for NOx**						
		Non-EGU Point Sources						
		* ICI Boilers - 40% SO2, 60% NOx reduction (ICI1)						
		Area Sources						
		* Consumer products - OTC model rule (SOLV2A)						
		* AIM coatings - OTC model rule (SOLV1A)						
		* Portable fuel containers - OTC model rule (SOLV3A)						
		Mobile Sources						
		* HDDV – reflashing and voluntary measures <$5,000/T						
		* Construction Equipment - voluntary measures < $5,000/T						
		* Low RVP fuel (IN, MI, OH counties)						

$PM_{2.5}$ Design Values (for sites w/ obs. value > 15.5 ug/m3)			2008	2009						2012														2018			
		Obs.	CAIR-full trading	CAIR-full trading	CAIR-budgets	EGU2-5 state	EGU1-5 state	All - min	All - max	CAIR-full trading	CAIR-restrict.	CAIR-budgets	EGU2-top 30	EGU2-100km	EGU2-5 state	EGU2-12 state	EGU1-5 state	EGU1(5)-IPM	EGU2(5)-IPM	Comm. Package	P.Team Option	All - min	All - max	CAIR-full trading	plus BART	EGU2-5 state	EGU2-12 state
			1a	1a	1d	2c	2e	3a	3b	1a	1b	1d	2a	2b	2c	2d	2e	2f	2g	4	5	3a	3b	1a	1c	2c	2d
Chicago	170310014	15.6		14.4	14.1	14.0	14.2	14.1	13.7	14.3	14.2	14.0	13.9	13.9	13.6	13.2	13.7	14.0	13.8	14.2	13.6	13.6	13.3	14.1	14.0	13.4	13.1
	170310022	15.9		14.8	14.5	14.3	14.5	14.4	14.1	14.6	14.6	14.4	14.2	14.2	13.9	13.6	14.0	14.3	14.1	14.5	13.9	13.9	13.7	14.4	14.3	13.7	13.4
	170310052	17.1		15.8	15.5	15.3	15.6	15.4	15.1	15.5	15.5	15.3	15.2	15.1	14.8	14.4	14.9	15.2	15.0	15.5	14.8	14.8	14.5	15.0	14.9	14.2	13.9
	170310057	15.6		14.5	14.2	14.0	14.2	14.1	13.8	14.3	14.3	14.1	14.0	13.9	13.6	13.3	13.7	14.0	13.8	14.2	13.6	13.6	13.4	14.1	14.0	13.5	13.1
	170310076	15.6		14.5	14.2	14.0	14.2	14.1	13.8	14.3	14.3	14.1	13.9	13.9	13.6	13.3	13.7	14.0	13.8	14.2	13.6	13.6	13.4	14.1	14.0	13.4	13.1
	170312001	15.6		14.5	14.2	14.0	14.2	14.1	13.8	14.3	14.3	14.1	14.0	13.9	13.6	13.3	13.7	14.0	13.8	14.2	13.6	13.6	13.4	14.1	14.0	13.5	13.1
	170313301	16.0		14.8	14.5	14.3	14.6	14.4	14.1	14.6	14.6	14.4	14.3	14.3	13.9	13.6	14.1	14.3	14.1	14.6	13.9	14.0	13.7	14.4	14.4	13.8	13.4
	170316005	16.4		15.3	15.0	14.8	15.0	14.9	14.5	15.1	15.1	14.9	14.7	14.7	14.4	14.0	14.5	14.8	14.6	15.0	14.4	14.4	14.2	14.9	14.8	14.2	13.9
Granite City/St. Louis	171191007	17.3		16.0	15.7	15.5	15.7	15.7	15.4	15.8	15.7	15.6	15.5	15.5	15.2	14.4	15.3	15.6	15.5	15.7	15.2	15.3	15.1	15.5	15.4	15.0	14.2
	171630010	16.2		14.9	14.7	14.5	14.7	14.7	14.4	14.7	14.7	14.6	14.5	14.5	14.2	13.4	14.3	14.5	14.4	14.7	14.2	14.2	14.1	14.5	14.4	14.0	13.2
Louisville	180190005	17.2		15.5	15.1	14.8	15.0	14.9	14.6	15.0	14.8	14.7	14.4	14.6	14.1	13.2	14.2	14.7	14.6	14.9	14.1	14.1	13.9	14.4	14.3	13.6	13.0
Jasper	180372001	15.5		13.8	13.5	13.2	13.4	13.4	13.0	13.5	13.3	13.2	13.0	13.2	12.6	11.8	12.7	13.2	13.0	13.5	12.6	12.7	12.4	13.0	13.0	12.2	11.6
Indianapolis	180970078	16.2		14.5	14.0	13.7	14.0	13.9	13.5	14.2	14.0	13.9	13.7	13.8	13.1	12.5	13.3	13.7	13.5	14.1	13.1	13.2	12.8	13.7	13.6	12.8	12.3
	180970083	16.6		14.8	14.4	14.1	14.3	14.3	13.8	14.5	14.3	14.2	14.1	14.1	13.4	12.9	13.6	14.1	13.8	14.5	13.5	13.5	13.2	14.0	14.0	13.1	12.6
Detroit	261630001	15.9		14.5	14.0	13.7	14.0	13.9	13.4	14.1	14.0	13.6	13.4	13.3	12.9	12.6	13.1	13.5	13.2	14.0	12.9	13.0	12.7	13.3	13.2	12.2	11.9
	261630015	17.3		15.8	15.2	14.9	15.3	15.1	14.7	15.3	15.3	14.8	14.6	14.6	14.1	13.7	14.3	14.7	14.5	15.2	14.1	14.2	13.9	14.4	14.4	13.4	13.0
	261630016	15.5		14.1	13.7	13.4	13.7	13.6	13.1	13.7	13.7	13.3	13.1	13.0	12.6	12.2	12.8	13.2	13.0	13.7	12.7	12.7	12.4	13.0	12.9	12.0	11.7
	261630033	19.3		17.7	17.1	16.8	17.2	17.0	16.6	17.1	17.1	16.7	16.4	16.4	16.0	15.6	16.1	16.5	16.3	17.1	16.0	16.0	15.7	16.1	16.0	15.0	14.7
	261630036	16.6		15.1	14.6	14.3	14.6	14.5	14.0	14.7	14.7	14.2	14.0	13.9	13.5	13.1	13.7	14.1	13.8	14.6	13.5	13.6	13.2	13.9	13.8	12.8	12.5
Cleveland	390350013	18.1		15.8	15.4	15.0	15.3	15.1	14.6	15.2	15.3	14.9	14.4	14.4	14.0	13.5	14.2	14.7	14.6	15.1	14.0	14.1	13.7	14.2	14.2	13.2	12.8
	390350027	16.5		14.4	13.9	13.5	13.8	13.7	13.2	13.8	13.9	13.5	13.1	13.0	12.6	12.2	12.8	13.3	13.2	13.7	12.6	12.7	12.3	12.9	12.8	11.9	11.5
	390350038	18.4		16.1	15.6	15.2	15.5	15.3	14.8	15.4	15.5	15.1	14.7	14.6	14.3	13.8	14.4	15.0	14.8	15.3	14.3	14.3	13.9	14.4	14.4	13.4	12.1
	390350044	16.7		14.6	14.2	13.7	14.0	13.9	13.4	14.0	14.1	13.7	13.3	13.2	12.9	12.4	13.0	13.6	13.4	13.9	12.9	12.9	12.5	13.1	13.0	12.1	11.8
	390350060	17.5		15.3	14.8	14.4	14.7	14.6	14.1	14.7	14.8	14.4	13.9	13.9	13.5	13.0	13.7	14.2	14.0	14.6	13.5	13.5	13.2	13.7	13.7	12.7	12.4
	390350065	16.1		14.1	13.6	13.2	13.5	13.4	12.9	13.5	13.6	13.2	12.8	12.7	12.3	11.9	12.5	13.0	12.9	13.4	12.3	12.4	12.0	12.6	12.6	11.6	11.3
Akron	391530017	16.4		14.4	14.0	13.6	13.8	13.7	13.2	13.8	13.8	13.5	13.2	13.1	12.8	12.3	12.9	13.4	13.2	13.7	12.8	12.8	12.4	12.9	12.9	12.0	11.7
	391530023	15.6		13.6	13.2	12.8	13.1	12.9	12.5	13.0	13.1	12.7	12.4	12.4	12.0	11.5	12.1	12.6	12.5	12.9	12.0	12.0	11.7	12.2	12.2	11.3	11.0
Canton	391510017	17.3		15.0	14.6	14.2	14.4	14.3	13.9	14.3	14.4	14.1	13.8	13.7	13.3	12.8	13.5	14.1	13.9	14.3	13.4	13.4	13.1	13.6	13.5	12.7	12.4
	391510020	15.7		13.6	13.2	12.8	13.0	12.9	12.5	13.0	13.0	12.7	12.4	12.4	12.0	11.5	12.1	12.7	12.5	12.9	12.0	12.0	11.7	12.2	12.2	11.4	11.0
Columbus	390490024	16.6		14.6	14.2	13.8	14.1	13.9	13.6	14.0	14.0	13.7	13.4	13.4	13.0	12.4	13.1	13.6	13.5	13.9	13.0	13.0	12.7	13.0	13.0	12.2	11.8
	390490025	16.0		14.1	13.7	13.3	13.6	13.4	13.0	13.5	13.5	13.2	12.9	12.9	12.5	11.9	12.6	13.1	13.0	13.4	12.5	12.5	12.2	12.5	12.5	11.7	11.3
	390490081	16.0		14.0	13.6	13.2	13.5	13.4	13.0	13.4	13.4	13.1	12.8	12.8	12.4	11.9	12.6	13.1	12.9	13.3	12.4	12.5	12.2	12.5	12.4	11.7	11.3
Cincinnati	390170003	16.1		14.2	13.8	13.4	13.7	13.5	13.0	13.7	13.6	13.4	13.1	13.1	12.6	11.9	12.8	13.3	13.1	13.6	12.6	12.6	12.2	13.1	13.0	12.2	11.7
	390170016	15.5		13.5	13.2	12.7	12.9	12.8	12.4	12.9	12.8	12.6	12.2	12.3	11.9	11.2	12.0	12.5	12.4	12.8	11.9	11.9	11.6	12.2	12.1	11.3	10.8
	390610014	17.7		15.5	15.1	14.6	14.9	14.7	14.2	14.8	14.7	14.5	14.1	14.2	13.7	13.0	13.8	14.4	14.2	14.7	13.7	13.7	13.4	14.0	13.9	13.0	12.5
	390610040	15.6		13.6	13.2	12.7	13.0	12.9	12.4	13.0	12.9	12.7	12.3	12.4	11.9	11.2	12.1	12.6	12.5	12.9	11.9	12.0	11.6	12.3	12.2	11.4	10.9
	390610042	16.8		14.6	14.2	13.7	14.0	13.9	13.4	14.0	13.9	13.7	13.3	13.3	12.8	12.1	13.0	13.5	13.4	13.9	12.9	12.9	12.5	13.2	13.1	12.2	11.7
	390610043	15.5		13.6	13.2	12.7	13.0	12.9	12.4	13.0	12.9	12.7	12.3	12.4	11.9	11.2	12.1	12.6	12.4	12.9	11.9	11.9	11.6	12.2	12.2	11.3	10.9
	390617001	16.3		14.2	13.8	13.3	13.6	13.5	13.0	13.6	13.5	13.3	12.9	13.0	12.5	11.8	12.7	13.2	13.0	13.5	12.5	12.5	12.2	12.8	12.7	11.9	11.4
	390618001	17.3		15.2	14.8	14.3	14.6	14.5	14.0	14.6	14.5	14.3	13.9	13.9	13.5	12.8	13.6	14.1	14.0	14.5	13.5	13.5	13.2	13.8	13.7	12.9	12.3
Dayton	391130032	15.5		13.7	13.3	12.8	13.1	13.0	12.5	13.2	13.3	12.9	12.5	12.5	12.1	11.5	12.2	12.7	12.6	13.1	12.1	12.1	11.7	12.3	12.3	11.4	11.0
Steubenville	390810016	18.3		16.3	16.1	15.7	15.9	15.8	15.6	15.9	16.1	15.7	15.5	15.5	15.2	14.7	15.3	15.9	15.8	15.8	15.2	15.3	15.1	16.2	16.2	15.6	15.3
	390811001	17.5		15.5	15.2	14.8	15.0	15.0	14.7	15.0	15.2	14.8	14.6	14.7	14.3	13.9	14.5	15.0	14.9	15.0	14.4	14.4	14.2	15.3	15.2	14.7	14.4
Huntington	390870010	15.7		14.2	14.0	13.7	13.8	13.7	13.5	13.7	13.6	13.5	13.3	13.3	13.1	12.4	13.2	13.8	13.7	13.6	13.1	13.1	12.9	13.2	13.2	12.7	12.3
Portsmouth	391450013	17.1		15.4	15.1	14.8	15.0	14.9	14.7	14.8	14.8	14.6	14.4	14.4	14.1	13.5	14.2	14.8	14.8	14.8	14.2	14.2	14.0	14.2	14.1	13.6	13.2
Louisville (KY)	210670014	15.6		13.6																							
	211110043	15.9		14.2																							
	211110044	16.6		14.8																							
	211110048	16.1		14.3																							
Pittsburgh (PA)	420030008	15.6		13.5																							
	420030064	21.0		18.4						18.0						16.9								18.0			17.2
	420031008	15.8		13.4																							
	420031301	16.8		14.6																							
	420033007	16.4		14.1																							
	420070014	15.9		14.0																							
	420210011	15.6		13.2																							
W. Virginia (WV)	540090005	16.7		14.7																							
	540110006	16.5		14.9																							

	540290011	15.8		13.9																							
	540291004	17.3		15.3						14.8						13.7								15.1			14.2
	540391005	17.1		15.2						14.6						13.4								14.0			13.1
	540511002	15.6		13.5																							
	541071002	16.1		14.1																							
O_3 Design Values (for sites w/ obs. value > 89.0 ppb)			2008	2009						2012														2018			
		Obs.	CAIR-full trading	CAIR-full trading	CAIR-budgets	EGU2-5 state	EGU1-5 state	All - min	All - max	CAIR-full trading	CAIR-restrict.	CAIR-budgets	EGU2-top 30	EGU2-100km	EGU2-5 state	EGU2-12 state	EGU1-5 state	EGU1(5)-IPM	EGU2(5)-IPM	Comm. Package	P.Team Option	All - min	All - max	CAIR-full trading	plus BART	EGU2-5 state	EGU2-12 state
			1a	1a	1d	2c	2e	3a	3b	1a	1b	1d	2a	2b	2c	2d	2e	2f	2g	4	5	3a	3b	1a	1c	2c	2d
Chicago	170310032	85.3	83.1	82.7	82.3	82.3	82.5	82.1	82.0	82.7	82.6	82.7	82.1	82.2	81.8	81.2	82.1	82.4	82.1	82.8	81.9	81.9	81.4	82.6			
NW Indiana	180892008	88.3	86.9	86.6	86.3	86.3	86.5	86.2	86.3	86.3	86.1	86.3	85.9	85.8	85.4	84.9	85.7	85.8	85.6	86.3	85.4	85.4	85.2	84.9			
	180910005	90.3	87.4	86.5	86.4	86.2	86.4	86.0	85.7	85.4	85.1	85.2	84.8	84.6	84.2	83.8	84.8	84.8	84.5	84.9	83.8	84.2	83.5	82.7			
	181411007	90.3	82.1	80.8	80.6	80.4	80.7	79.8	79.0	78.6	78.5	78.6	77.7	77.6	77.1	76.8	77.8	78.2	77.7	78.0	76.5	77.0	75.7	74.6			
Indianapolis	180571011	93.7	85.2	83.7	83.6	82.9	83.5	82.8	81.6	82.0	80.6	81.6	81.3	81.9	79.7	79.2	80.4	80.6	79.6	81.0	78.6	79.2	77.9	75.9			
	180590003	91.3	85.1	83.8	83.6	83.0	83.6	82.8	81.8	82.1	80.7	81.8	81.3	81.9	79.8	79.3	80.6	80.8	79.8	81.2	78.9	79.4	78.2	76.0			
	180950010	91.7	83.1	81.6	81.5	80.7	81.3	80.6	79.4	79.5	78.0	79.1	78.7	79.3	77.2	76.5	78.0	78.2	77.2	78.5	76.2	76.6	75.3	73.1			
	180970050	90.0	84.8	83.7	83.5	82.8	83.5	82.4	81.4	82.4	81.1	82.0	81.0	82.0	79.9	79.5	80.7	80.9	79.9	81.3	78.9	79.3	78.1	76.8			
	181450001	91.3	84.2	82.9	82.6	81.9	82.6	81.6	80.3	81.0	79.8	80.7	80.2	80.6	78.5	77.7	79.3	79.6	78.6	79.9	77.4	77.9	76.5	75.3			
Holland	260050003	94.0	84.9	83.4	83.4	83.1	83.3	82.7	81.9	81.0	80.7	80.8	80.1	80.0	79.6	79.2	80.3	80.5	80.0	80.2	78.8	79.3	78.3	76.5			
Cass County	260270003	90.7	81.7	80.5	80.2	80.1	80.4	79.5	78.7	78.1	77.9	78.1	77.5	77.5	76.9	76.5	77.4	77.8	77.4	77.5	76.2	76.6	75.6	73.6			
Muskegon	261210039	90.0	82.7	81.5	81.5	81.2	81.4	80.8	80.2	79.4	79.0	79.1	78.7	78.6	78.3	77.9	78.8	78.9	78.6	78.5	77.4	77.8	77.0	75.5			
Detroit	260990009	92.3	86.3	85.3	85.2	85.0	85.2	84.0	83.4	83.5	83.6	83.8	83.2	83.2	82.7	82.3	83.0	83.5	83.1	83.0	82.3	81.9	80.9	81.4			
	260991003	90.0	84.3	83.3	83.2	83.0	83.2	82.4	81.7	81.9	81.6	81.8	81.4	81.4	80.9	80.5	81.3	81.5	81.1	81.2	80.3	80.3	79.5	79.6			
Cleveland	390071011	95.7	84.7	82.7	82.8	81.8	82.5	82.0	80.7	80.2	79.9	79.8	78.6	78.0	77.6	77.2	78.6	78.6	78.3	79.1	76.5	77.3	76.1	73.0			
	390550004	99.0	90.3	88.8	88.8	88.3	88.6	87.7	86.9	86.2	85.7	85.9	85.3	85.4	84.9	84.3	85.4	85.7	85.4	85.1	83.8	84.1	83.2	80.1			
	390850003	92.7	84.2	82.8	82.8	82.3	82.6	81.8	81.1	80.6	80.0	80.2	79.7	79.7	79.3	78.7	79.8	80.0	79.5	79.6	78.2	78.5	77.7	75.5			
	391331001	91.0	80.9	79.4	79.3	79.0	79.3	78.6	77.7	76.5	76.3	76.4	75.9	75.9	75.5	75.1	75.8	76.2	75.9	75.6	74.6	74.8	73.9	69.7			
Akron	391530020	93.3	83.0	81.4	81.4	81.0	81.3	80.7	79.8	78.5	78.2	78.3	78.0	77.9	77.6	77.0	77.9	78.1	77.8	77.6	76.6	76.8	76.0	71.6			
Columbus	390490029	93.0	84.1	82.6	82.6	82.1	82.4	81.9	80.9	80.2	79.9	80.0	79.6	79.8	79.1	78.5	79.4	79.5	79.3	79.2	78.0	78.1	77.2	73.1			
	390410002	89.0	79.2	77.7	77.8	77.3	77.6	77.2	76.3	75.6	75.1	75.3	74.9	75.1	74.4	73.7	74.8	74.9	74.7	74.6	73.4	73.7	72.8	68.9			
Cincinnati	390170004	89.7	83.4	82.4	82.4	81.7	82.2	81.3	80.5	80.3	79.9	80.1	79.1	79.1	78.7	77.9	79.2	79.7	79.4	81.3	77.7	77.9	77.2	75.2			
	390250022	89.0	82.6	81.8	81.6	80.9	81.4	80.8	80.0	79.8	79.6	79.6	77.8	78.0	77.6	76.7	78.4	78.7	78.4	78.9	76.7	77.4	76.3	74.9			
	390271002	94.3	84.8	83.5	83.4	82.3	83.1	82.5	81.3	81.1	80.1	80.7	78.8	79.0	78.4	77.3	79.2	79.2	78.7	79.8	77.1	77.8	76.8	74.5			
	390610006	90.3	85.4	84.7	84.6	83.9	84.4	83.6	82.9	82.9	82.5	82.8	81.6	81.8	81.4	80.5	81.8	82.3	82.0	82.0	80.3	80.6	79.9	78.5			
Toledo	390950034	90.0	81.7	80.5	80.3	79.7	80.3	79.4	78.3	78.3	77.9	78.1	76.8	76.8	76.2	75.9	76.9	77.5	76.5	77.5	75.4	75.8	74.6	72.9			
Youngstown	391550011	91.0	80.1	78.6	78.3	78.0	78.4	77.8	76.9	75.6	75.3	75.6	75.1	74.6	74.2	73.5	74.6	74.8	74.8	75.0	73.6	73.9	73.0	69.4			
Kenosha	550590002	96.0	90.8	89.8	89.8	89.6	89.7	89.0	88.6	88.2	87.8	87.9	87.6	87.6	87.3	86.8	87.8	87.7	87.6	87.3	86.4	86.7	86.0	84.6			
	550590019	98.3	93.0	92.0	91.9	91.7	91.9	91.2	90.7	90.3	89.9	90.0	89.7	89.7	89.4	88.9	89.9	89.8	89.7	89.4	88.5	88.8	88.1	86.7			
Milwaukee	550790085	91.0	85.4	84.2	84.2	83.9	84.1	83.5	82.9	82.3	81.9	82.0	81.5	81.5	81.2	80.8	81.7	81.8	81.4	81.1	80.0	80.2	79.5	78.7			
	550791025	91.0	85.2	84.9	84.2	84.7	84.9	83.5	83.0	82.4	82.8	83.0	81.9	82.0	81.7	81.2	82.0	82.8	82.7	82.2	81.4	81.5	80.2	79.7			
Kewaunee	550610002	89.3	82.5	81.0	81.3	80.7	80.9	80.5	79.8	79.1	78.3	78.5	78.5	78.4	78.1	77.6	78.5	78.4	78.1	77.6	76.6	76.9	76.4	74.9			
Ozaukee County	550890009	93.0	86.7	85.4	85.4	85.1	85.3	84.6	84.0	82.9	82.5	82.6	82.2	82.2	81.9	81.5	82.4	82.4	82.1	81.7	80.6	80.9	80.1	79.2			
Racine	551010017	91.7	85.9	84.9	84.9	84.7	84.8	84.2	83.7	82.9	82.7	82.8	82.4	82.4	82.1	81.7	82.5	82.6	82.5	82.1	81.4	81.5	80.8	79.6			
Sheboygan	551170006	97.0	90.0	88.9	88.6	88.5	88.8	87.8	87.1	86.4	86.1	86.3	85.7	85.7	85.3	84.9	85.8	86.1	85.8	85.4	84.3	84.5	83.6	82.5			
Door County	550290004	91.0	83.6	81.8	82.2	81.5	81.7	81.6	80.8	79.3	78.5	78.6	78.6	78.6	78.3	77.8	78.8	78.4	78.2	77.9	76.8	77.2	76.7	75.2			
St. Louis (MO)	291831002	90.0	86.1	85.2	85.3	85.2	85.2	85.1	85.0	84.0	83.7	83.9												80.6			
	291831004	90.0	83.3	82.2																				76.0			
Erie-Niagara (PA-NY)	420490003	89.0	79.5	78.1																				69.8			
	360130006	93.0	83.2	81.8																				73.1			
	360290002	95.7	84.5	83.1																				74.0			
Pittsburgh (PA)	420030008	89.3	79.8	78.9																				73.8			
	420030010	90.7	81.0	80.1																				74.9			
	420030067	89.3	77.6	76.6																				71.6			
	420031005	91.3	81.0	79.8																				72.9			
	420050001	90.7	79.0	77.6																				70.4			
	420070002	91.3	81.5	80.0																				73.6			
	420070005	89.7	79.9	78.7																				72.3			
	420850100	91.3	80.0	78.5																				69.5			

The attainment test was applied consistent with USEPA's ozone and draft $PM_{2.5}$ modeling guidance. The "base" year design value was calculated as the weighted average of the design values for three 3-year periods (2000-2002, 2001-2003, and 2002-2004). The relative reduction factors were calculated using the peak 3x3 grid cell around the monitor and, for ozone, assuming a threshold of 85 ppb.[3]

The modeling results for Scenario 1 are provided in Table 2, and Figures 7 and 8. Several key findings should be noted

- 2008: This year was modeled because it represents the planning year for basic ozone nonattainment areas (attainment date of 2009). The modeling shows that two basic nonattainment areas (Cincinnati and Indianapolis) are close, but still slightly above the standard.

- 2009: This year was modeled because it represents the planning year for moderate ozone and PM2.5 nonattainment areas (attainment date of 2010). The modeling shows existing control programs will improve air quality for ozone and $PM_{2.5}$, but will not be enough to provide for attainment everywhere.

- 2012: This year was modeled to assess the effect of additional emission reductions from existing control programs. The modeling shows that these control programs will further improve air quality for ozone and PM2.5, but will also not be enough to provide for attainment everywhere.

- 2018: This year was modeled to assess the effect of additional emission reductions from existing control programs (e.g., full implementation of CAIR). The modeling shows that almost all sites are expected to attain for ozone, but several sites are still above the standard for PM2.5.

The number of monitors with design values above the standard are as follows:

	Ozone			**PM2.5**		
State	2002	2009	2012	2002	2009	2012
IL	3	0	0	11	3	3
IN	22	2	2	10	1	1
MI	15	1	0	6	3	2
OH	40	1	1	31	7	4
WI	13	4	3	---	---	---
	93	8	6	58	14	10

[3] Alternative modeling, which was conducted as part of a weght-of-evidence demonstration, used different assumptions for calculating the base year design value and the relative reduction factors.

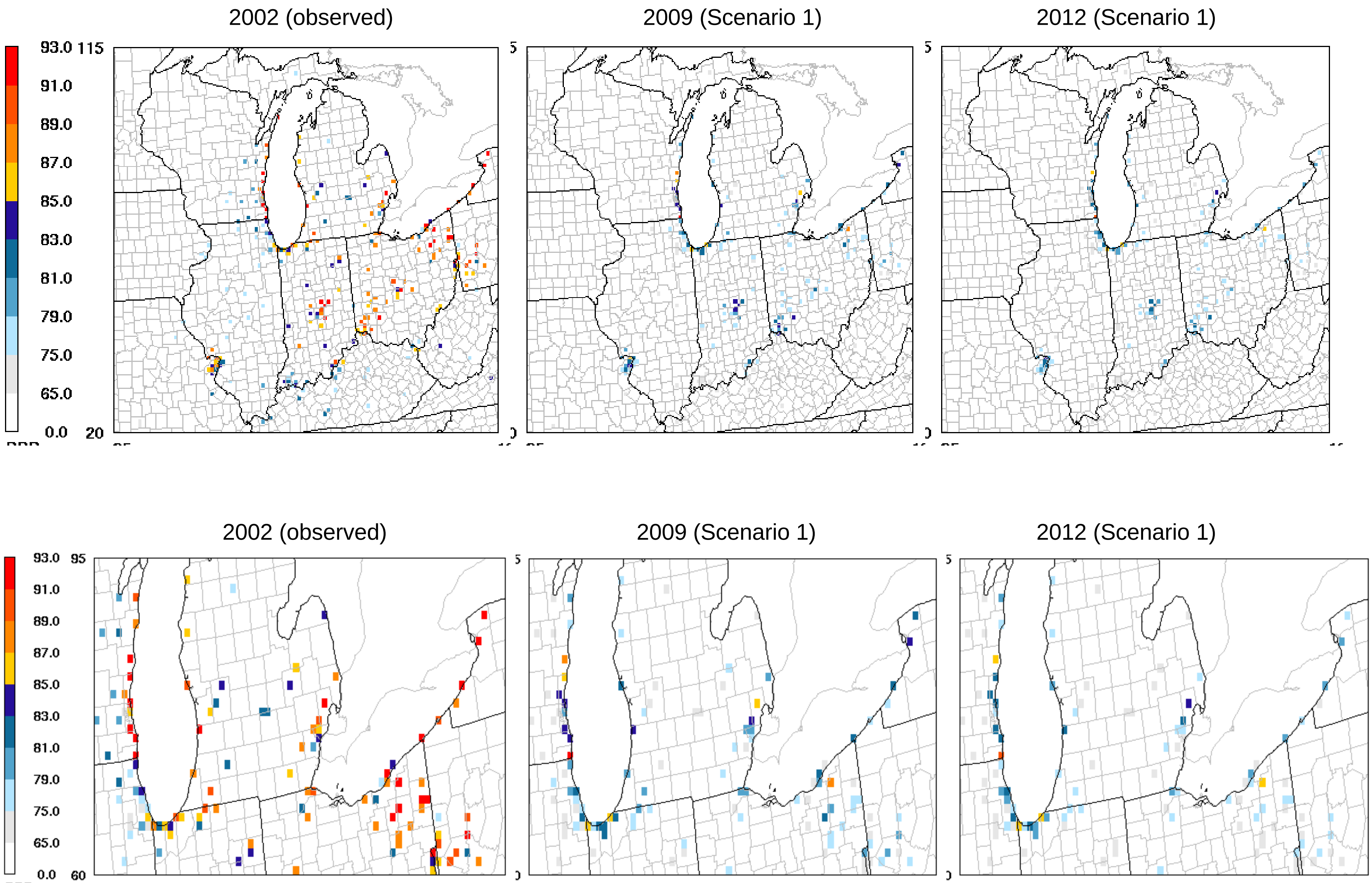


Figure 7. Observed base year and projected future year design values for ozone

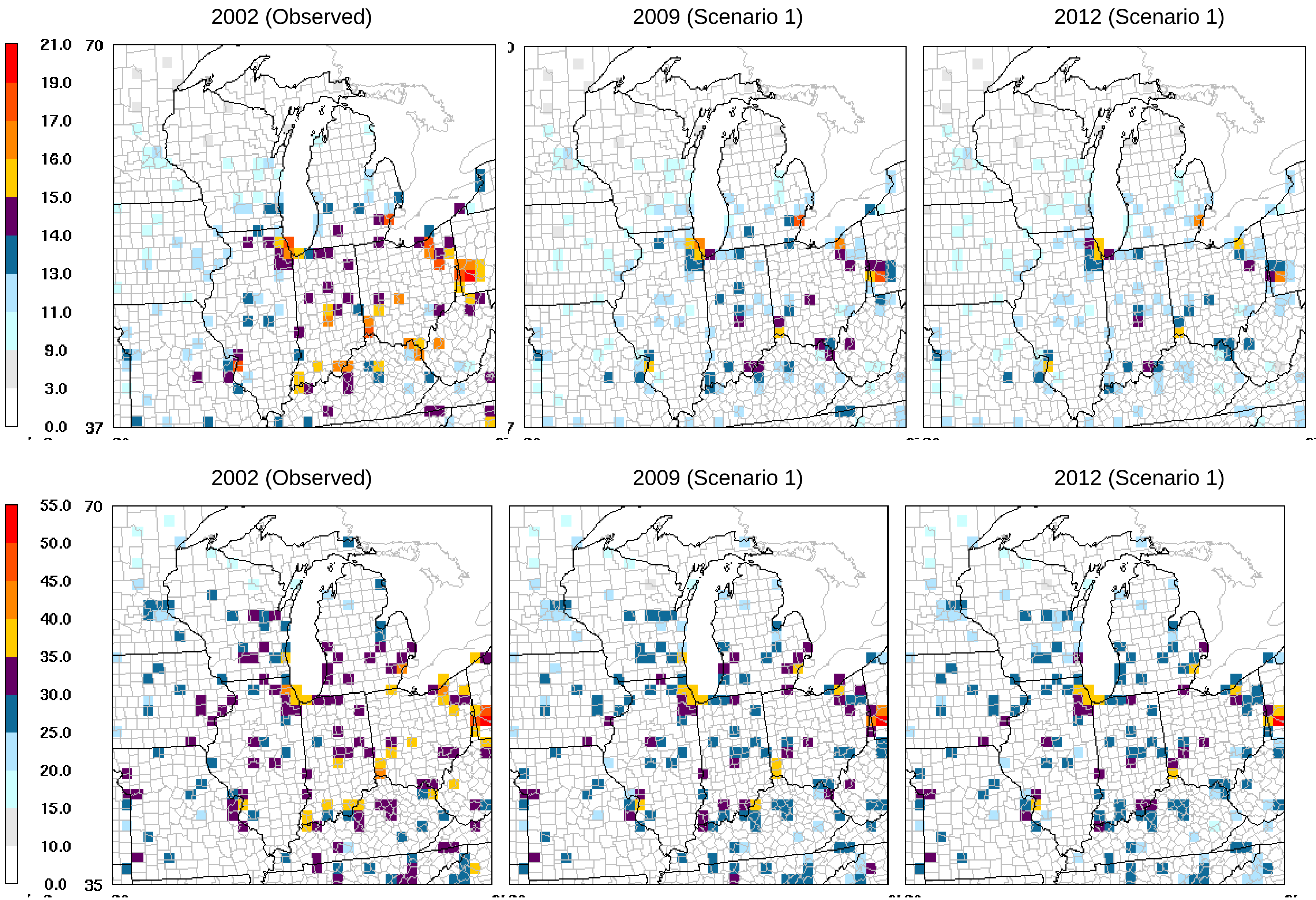


Figure 8. Observed base year and projected future year design values for $PM_{2.5}$ - annual (top) and 24-hour (bottom)

In summary, the residual nonattainment areas include the Lake Michigan area and Cleveland for ozone, and Chicago, Granite City, Detroit, Cincinnati, Cleveland, Louisville, Steubenville, and Portsmouth for $PM_{2.5}$ (see Figures 9a and 9b).

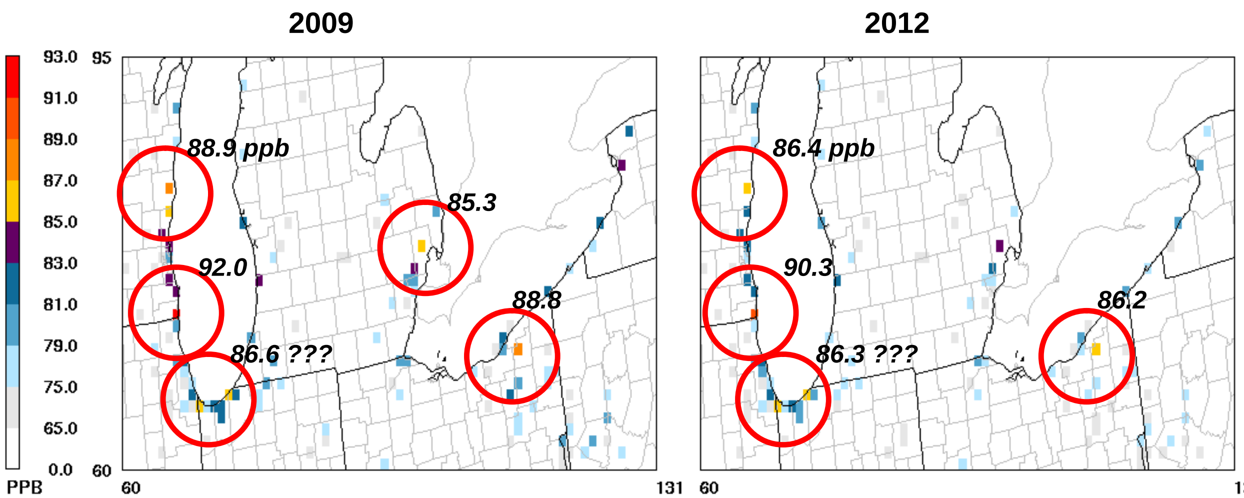


Figure 9a. Residual Nonattainment Areas for Ozone

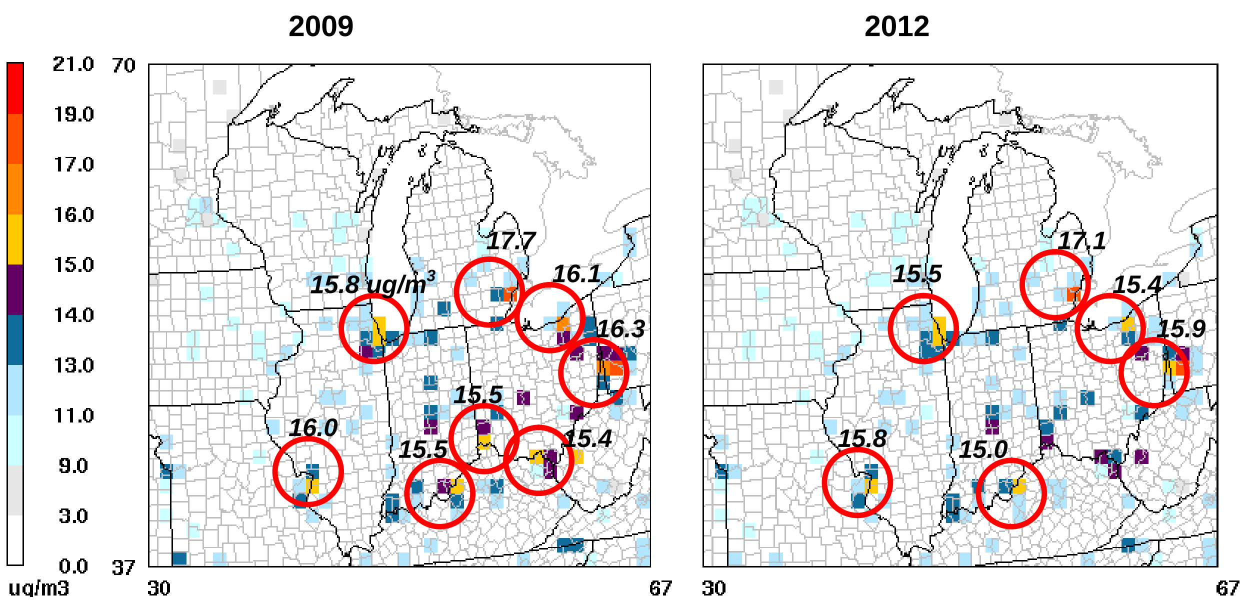


Figure 9b. Residual Nonattainment Areas for PM2.5

The 2009 and 2012 modeled ozone and PM2.5 design values are shown for several key monitors in Figure 10. Also included in the figure are the modeled design values from USEPA's final CAIR modeling ("Technical Support Document for the Final Clean Air Interstate Rule, Air Quality Modeling", March 2005). As can be seen, the LADCO and USEPA results are generally consistent.

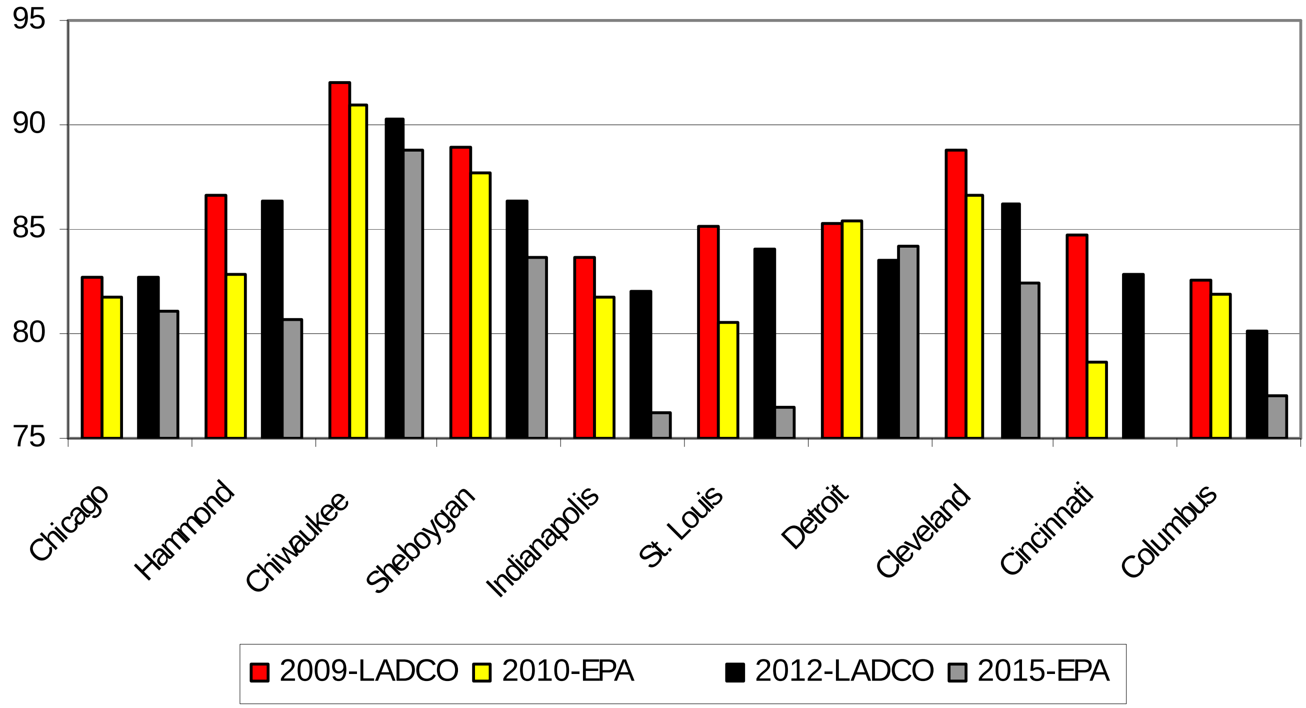


Figure 10a. LADCO v. EPA Modeling Results for Existing Control Measures (Ozone)

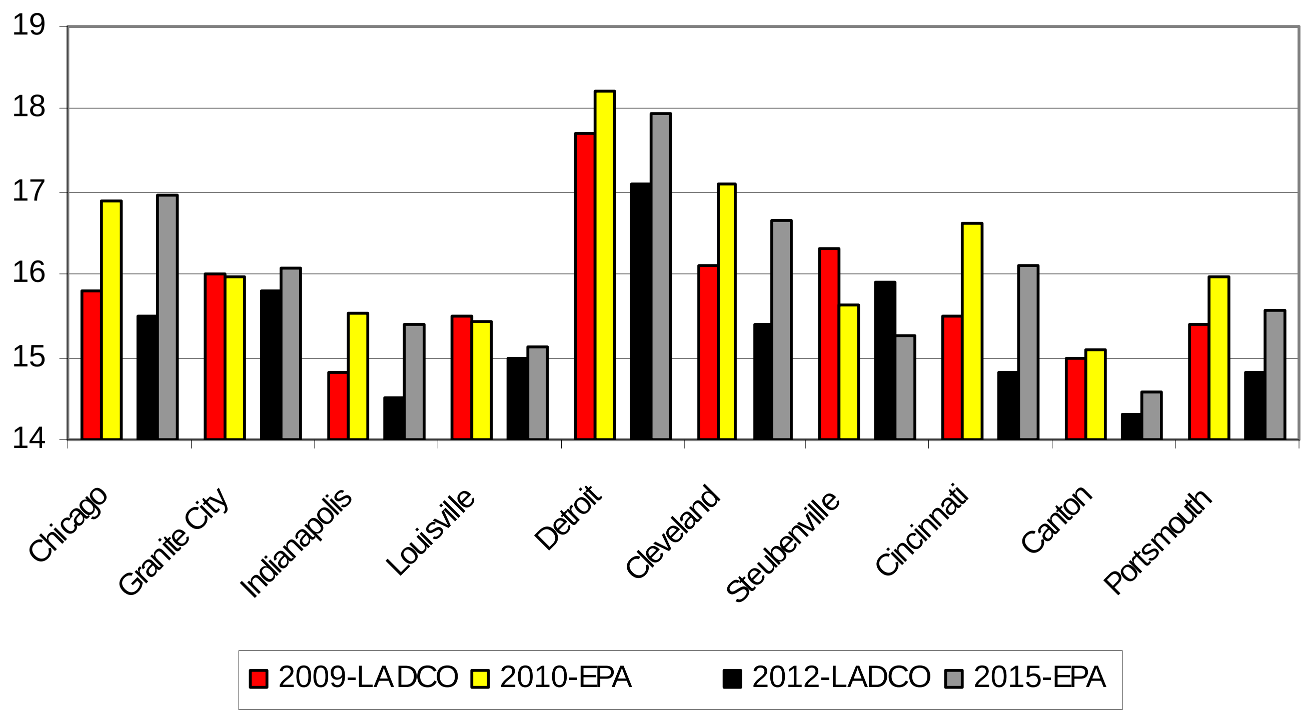


Figure 10b. LADCO v. EPA Modeling Results for Existing Control Measurs (PM2.5)

Scenario 2: This scenario reflects Scenario 1a plus the additional SO2 and NOx candidate control measures in the "Interim White Paper, Source Category: Electric Generating Units" (January 14, 2005):

2a reflects EGU2[4] for the top 30 EGUs in the 5-state region (based on Q/d)
2b reflects EGU2 for all EGUs within 100 km of a residual nonattainment area
2c reflects EGU2 throughout the 5-state LADCO region
2d reflects EGU2 throughout the 5-state LADCO region plus seven neighboring states: MN, IA, MO, KY, TN, WV, and PA
2e reflects EGU1 throughout the 5-state LADCO region
2f reflects EGU1 throughout the 5-state LADCO region based on recent IPM modeling
2g reflects EGU2 throughout the 5-state LADCO region based on recent IPM modeling

Scenario 3: This scenario reflects Scenario 2 plus additional white paper controls for stationary and mobile sources

Scenario 3a reflects the minimum control level for the EGU, non-EGU point, and area source White Paper controls, plus chip reflashing for HDDVs and a "highly cost effective" voluntary/incentive control program for HDDVs and construction equipment (i.e., < $5,000/T)
Scenario 3b reflects the maximum control level for the EGU, non-EGU point, and area source White Paper controls, plus chip reflashing for HDDVs and a "cost effective" voluntary/incentive control program for HDDVs, and construction and agricultural equipment (i.e., < $10,000/T)

Scenario 4: This scenario reflects Scenario 1a plus the additional control measures under discussion by the MW and NE State Commissioners:

Non-EGU	ICI1
Area	AIM, consumer products, and portable fuel containers
On-Road	Reflashing (see discussion under Scenario 3)

In addition, the Commissioners have discussed a voluntary retrofit program (although it is unclear whether the objective is to reduce NOx, VOC, and/or PM) and a regional gasoline. For the purposes of this model run, the Scenario 3a on-road and nonroad controls were assumed to reflect these possible other controls.

Scenario 5: This scenario reflects Scenario 1a plus the additional control measures identified by the LADCO Project Team as a possible control option:

EGU	EGU1 for SO2, EGU2 for NOx
Non-EGU	ICI1
Area	AIM, consumer products, and portable fuel containers
On-Road	Reflashing (see discussion under Scenario 3)
	HDDV voluntary programs (diesel retrofits)
	Low RVP fuel
Nonroad	Construction equipment voluntary programs (diesel retrofits)

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4 EGU2 and EGU1 in Scenarios 2a – 2e were derived by applying control factors developed by MACTEC. The derivation of these control factors is explained in "Identification and Evaluation of Candidate Control Measures", prepared by MACTEC, Aprl 14, 2005.

In addition, the Project Team identified organic carbon control measures, case-by-case point source controls, and state programs (e.g., RACT rules). For the purposes of this model run, no emission reductions were assumed for these other controls due to the lack of specific control information.

The incremental air quaiity benefit for various control measures is shown in Figure 11. Although the incremental amounts appear to be small, they are actually quite significant when viewed in context of the degree of nonattainment (i.e., the average amount of nonattainment is 7 ppb for ozone and 1.3 ug/m3 for PM2.5).

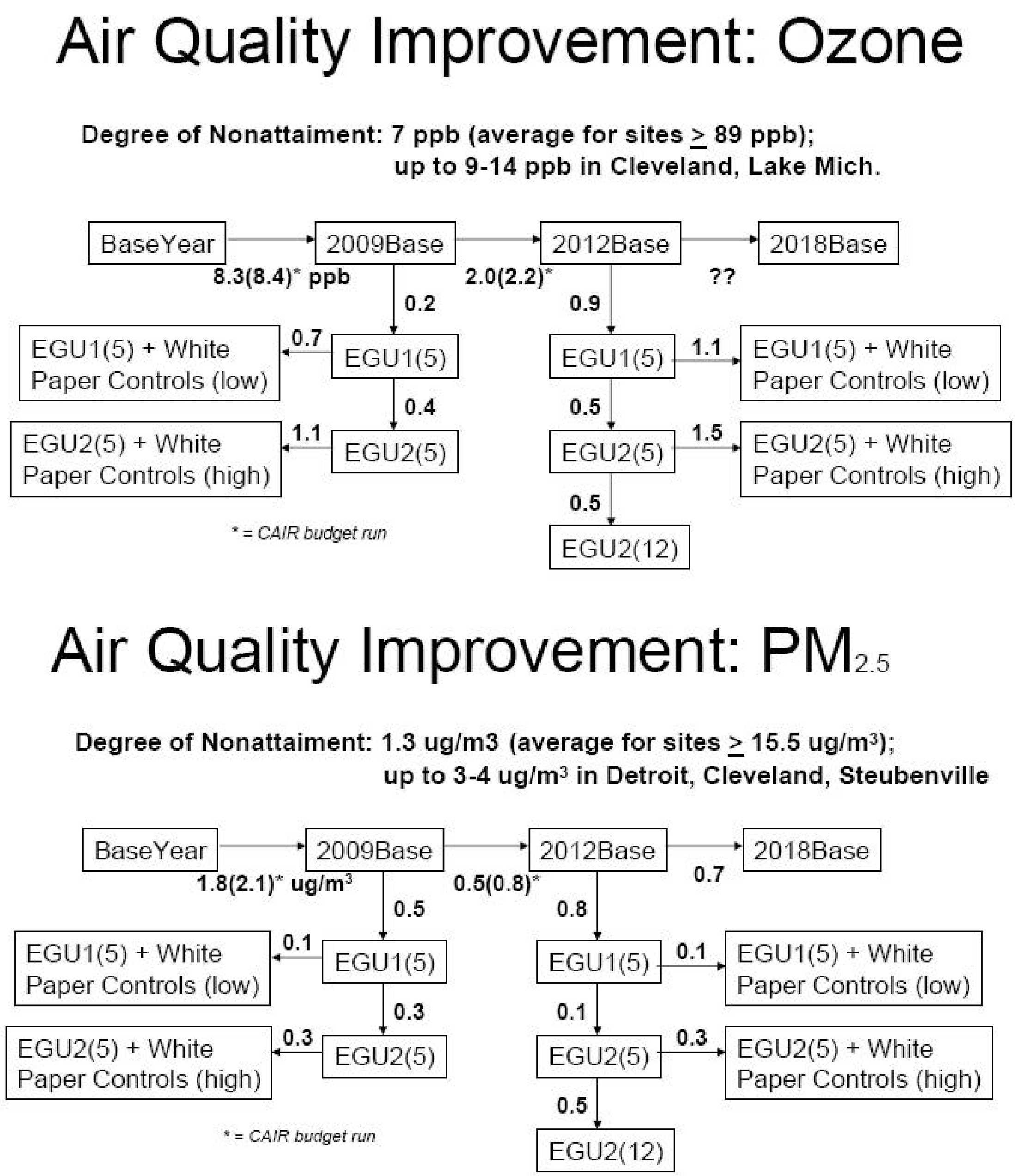

Figure 11. Average Air Quality Improvement for Ozone and PM2.5

The ozone and PM2.5 modeling results for the key nonattainment monitors for some of the future year scenarios are provided in Figures 12 and 13. Several observations on these results should be noted:

- Existing control programs will improve air quality, but are not enough to provide for attainment (even with additional emission reductions occurring by 2012).
- Attainment by 2009 could not be demonstrated, even with all the candidate control measures at their maximum control level.
- Attainment by 2012 appears to be possible with a combination of existing control programs and several candidate control measures.

The modeling results for visibility are shown in Figure 14 for Class I areas in the upper Midwest and other parts of the eastern U.S., compared to the uniform rate of progress line.[5] (The values presented here are based on the new IMPROVE equation.)

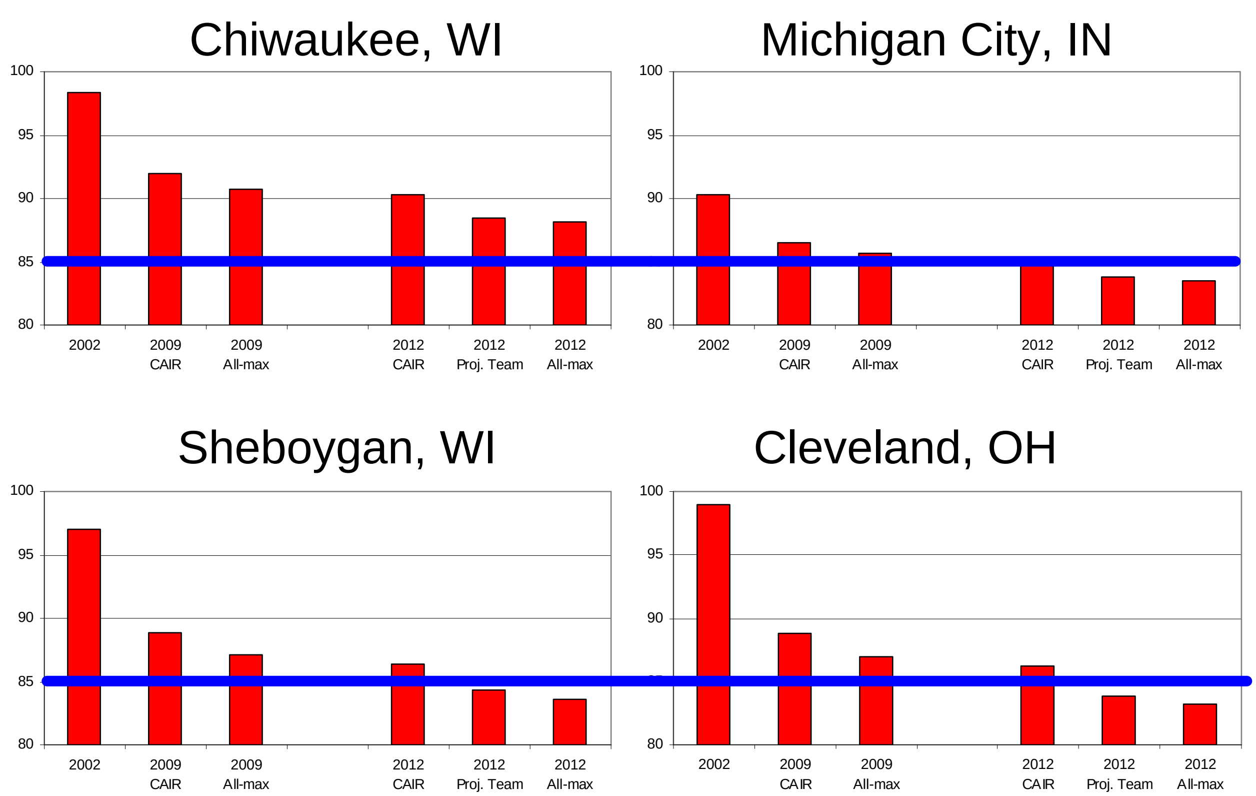

Figure 12. Future Year Ozone Design Values – Round 4 Scenarios

5 The haze requirement is to achieve reasonable progress by 2018 (i.e., the first milestone year for haze). A determination of reasonable progress for a given strategy is to be based on four statutory factors (i.e., costs, timing, energy impacts, and remaining useful life for the affected sources), as well as how the resulting visibility level compares with the uniform rate of progress. Only the comparison with the uniform rate of progress line is addressed here.

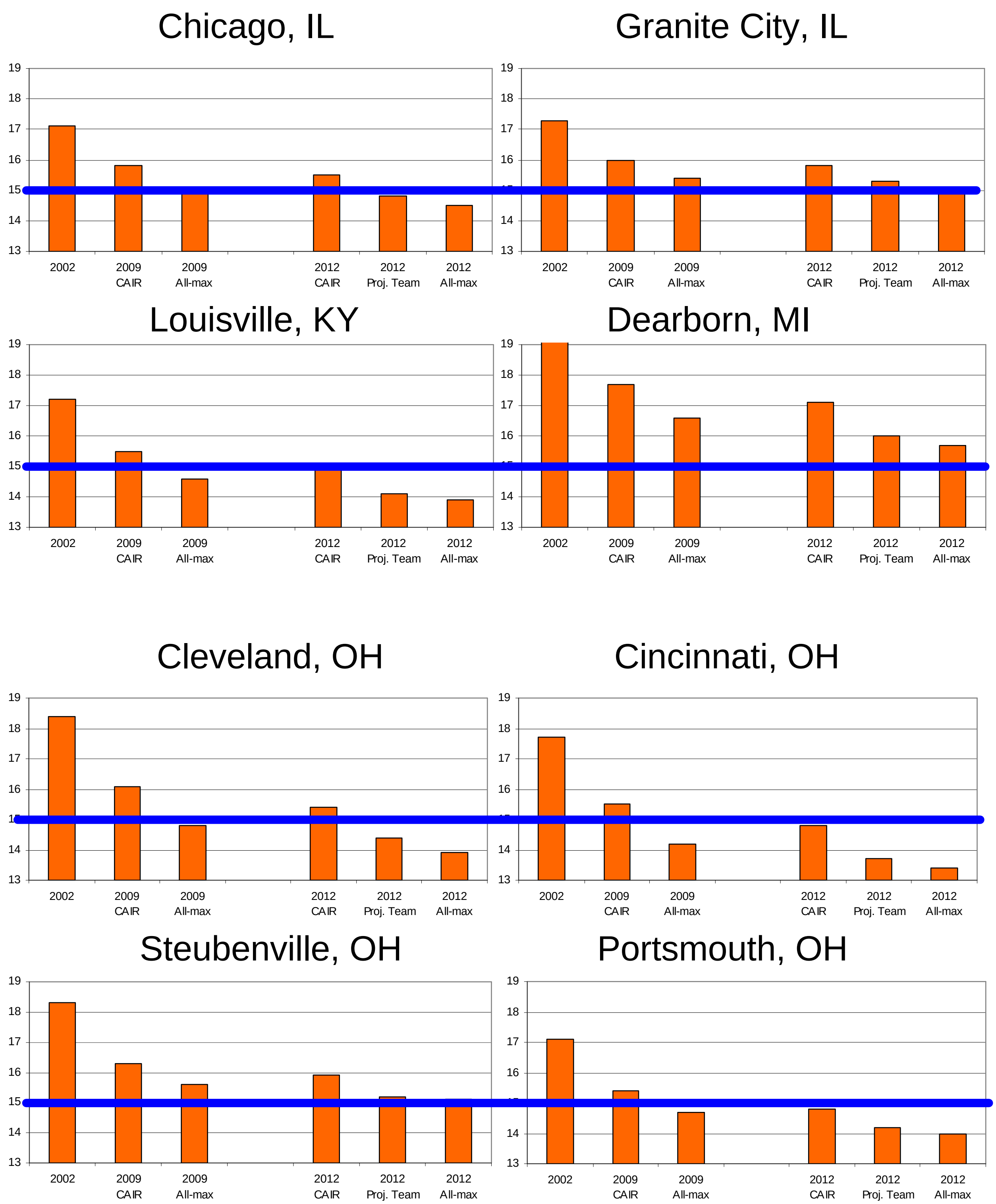

Figure 13. Future Year PM2.5 Design Values – Round 4 Scenarios

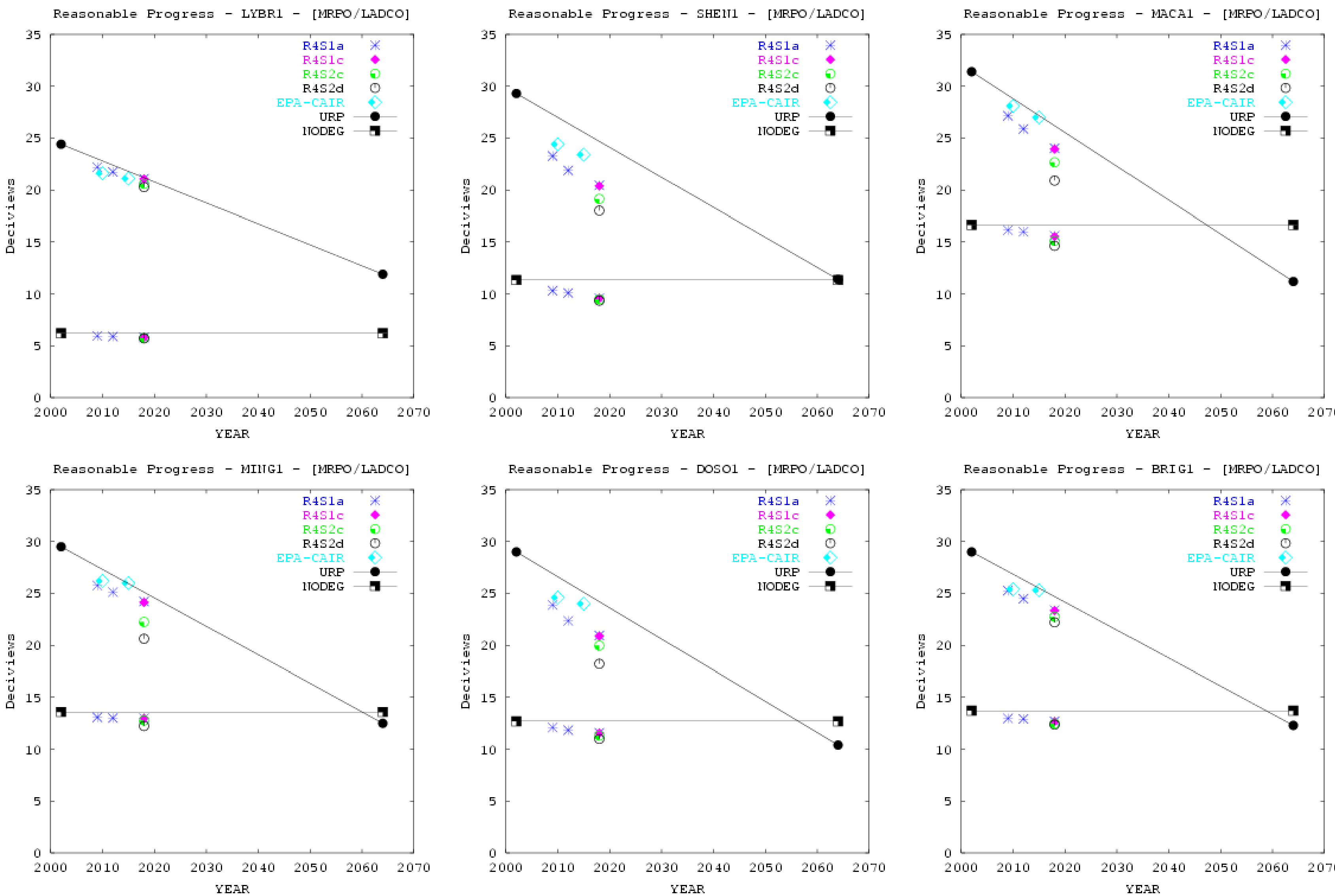

Figure 14. Future Year Visibility Levels – Round 4 Scenarios

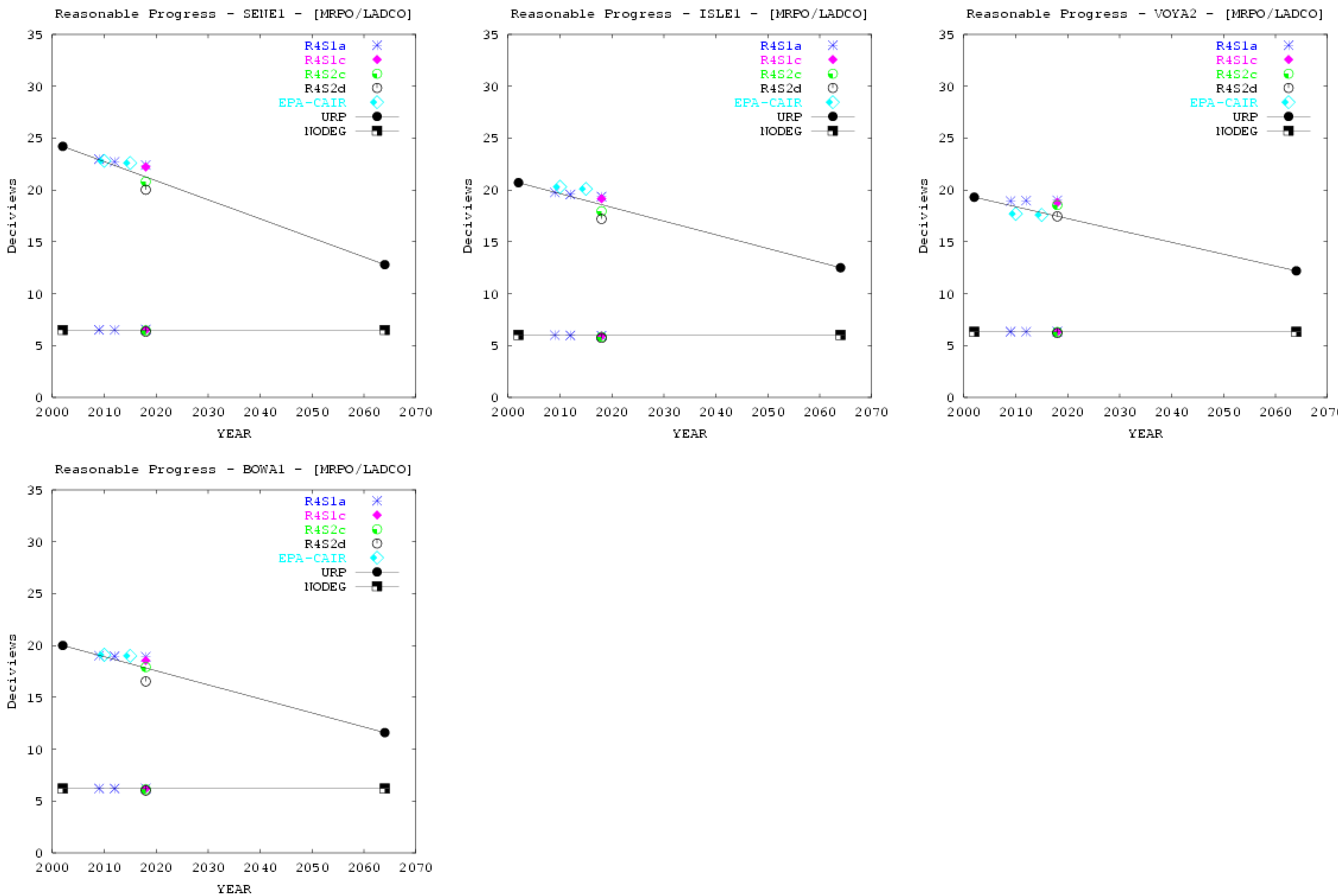

Figure 14. Future Year Visibility Levels – Round 4 Scenarios (continued)